L A S A AMPLITUDE SCATTER

NOVEMBER 2, 1966

REPORT No. LL-2

Prepared for

LINCOLN LABORATORIES
MASSACHUSETTS INSTITUTE of TECHNOLOGY

EARTH SCIENCES, A TELEDYNE COMPANY

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TABLE OF CONTENTS

	Page No.
FOREWARD	
ABSTRACT	
INTRODUCTION	1
PROCEDURE	1
1. LASA-UBSO	1
2. LASA-TFSO	2
CONCLUSIONS	3
APPENDIX A	

FOREWARD

The work documented in this report is part of a study of amplitude anomalies observed at the Large Aperture Seismic Array (LASA) in Montana.

This report was written by D. E. Frankowski. Assistance was provided by A. L. Kurtz, R. D. Mierley and P. A. Santiago. The project director was P. W. Broome.

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Chief, Lincoln Laboratory Office

ABSTRACT

Seismic signal amplitude scatter is shown by demonstration to be characteristic of present seismic arrays rather than a unique characteristic of LASA.

INTRODUCTION

It has been observed that there is considerable scatter in signal amplitudes recorded at LASA for a typical event. It is the purpose of this paper to demonstrate that the amplitude scatter at LASA is not a unique characteristic of this array but rather a common property of seismic arrays.

PROCEDURE

LASA amplitudes were compared to Uinta Basin Seismological Observatory (UBSO) and Tonto Forest Seismological Observatory (TFSO) amplitudes.

1. LASA-UBSO

   1.1 Since LASA is much larger than UBSO, the center instrument plus the 2-ring, 3-ring, and 4-ring instruments from a LASA subarray were used to simulate an array similar in size and configuration to UBSO (Figure 1). This was done for the AO, B2, and F4 subarrays.

   1.2 The amount of LASA amplitude data available was limited due to the choice of instruments used in this study. (No 16 mm film was available) LASA amplitudes for three Mexican and two Kurile Islands events were obtained from a computer program. UBSO amplitudes for two Mexican and two Kurile Islands events were obtained from analysts' observa-

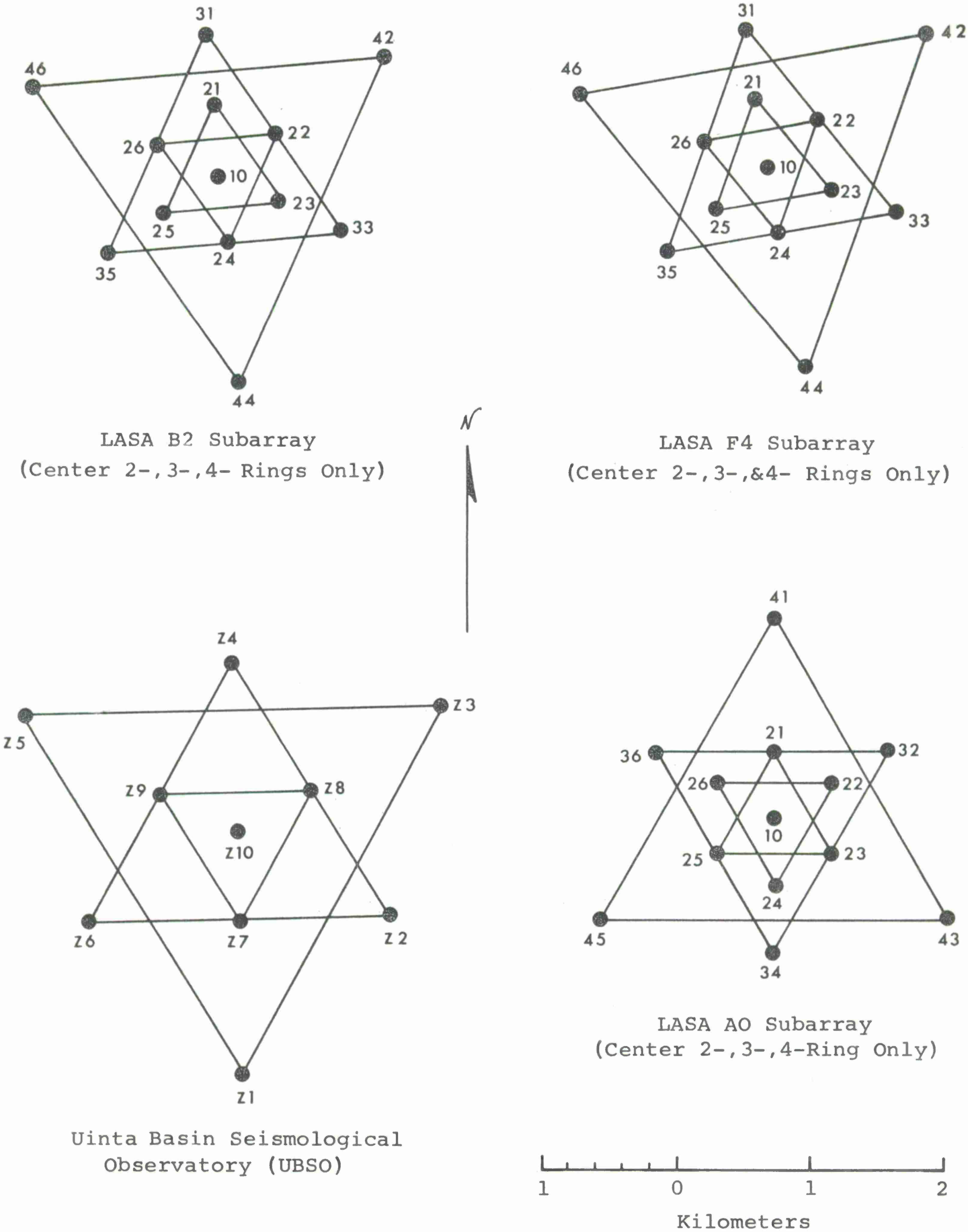

31
42
46
21
26
22
10
23
25
33
35
24
44
LASA B2 Subarray
(Center 2-,3-,4- Rings Only)
N
31
42
46
21
22
26
10
23
25
33
24
35
44
LASA F4 Subarray
(Center 2-,3-,&4- Rings Only)
Z4
Z3
Z5
Z9
Z8
Z10
Z6
Z7
Z2
Z1
Uinta Basin Seismological
Observatory (UBSO)
41
21
36
32
26
22
10
25
23
24
45
43
34
LASA AO Subarray
(Center 2-,3-,4-Ring Only)
1
0
1
2
Kilometers

Figure 1

tions of 16 mm film. Table 1 shows these data and a measure of the amplitude scatter at each array.

1.3 Figures 2 and 3 show the normalized amplitudes* plotted for each station for the two source regions. It is seen from this plot that the normalized amplitude scatter at each LASA station is no greater than the scatter observed at UBSO, even though the LASA scatter is greater over single events as shown in Table 1.

2. LASA-TFSO

2.1 An array similar to LASA in size and configuration can be simulated at TFSO if the TFSO extended array is included.

2.2 TFSO signal amplitudes for seven Aleutian Islands events were computed from analysts' observations. (The events used for each subarray were not the same group because the two arrays were not in operation at the same time.) Tables 2A and 2B show these data and a measure of the amplitude scatter at each array.

2.3 Figure 4 shows the normalized amplitudes plotted for each station. It is seen from

*The procedure used to normalize amplitudes is described in Appendix A.

UBSO AMPLITUDES (MILLIMICRONS)

STATION	KURILE #1	KURILE #2	MEXICO #3	MEXICO #4
Z1	13	19	11	25
Z2	12	19	9	26
Z3	13	18	12	28
Z4	12	17	9	24
Z5	12	25	11	28
Z6	13	19	10	27
Z7	12	26	11	25
Z8	11	19	11	23
Z9	11	18	11	22
Z10	11	20	12	27
MEAN	12	20	10.7	25.5
STD. DEV.	0.80	3.02	1.06	2.06
STD. DEV./MEAN	0.067	0.151	0.096	0.081

LASA AO AMPLITUDES (MILLIMICRONS)

STATION	KURILE #1	KURILE #2	MEXICO #3	MEXICO #4	MEXICO #5
AO 10	21	9	12	NO DATA	15
AO 21	23	11	.25		15
AO 41	24	9	.24		14
AO 22	24	10	.17		17
AO 32	31	12	.28		18
AO 23	25	No Data	No Data		15
AO 43	31	11	.15		16
AO 24	33	12	.19		25
AO 34	28	12	.10		15
AO 25	28	13	.20		16
AO 45	35	15	.30		18
AO 26	28	13	.26		22
AO 36	27	12	.24		16
MEAN	27.5	11.6	20.8		17.1
STD. DEV.	4.25	3.63	6.38		3.06
STD. DEV./MEAN	0.154	0.313	.307		0.179

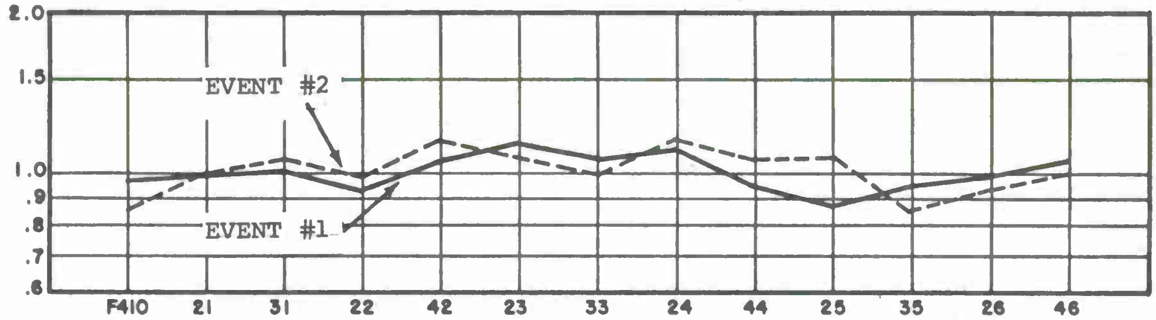
LASA B2 AMPLITUDES (MILLIMICRONS)

STATION	KURILE #1	KURILE #2	MEXICO #3	MEXICO #4	MEXICO #5
B2 10	43	18	22	69	19
B2 21	48	23	33	89	23
B2 31	48	18	25	70	20
B2 22	50	23	38	88	26
B2 42	51	19	42	77	24
B2 23	52	28	42	91	26
B2 33	51	21	33	89	37
B2 24	53	26	31	82	31
B2 44	48	32	43	99	40
B2 25	60	30	34	91	33
B2 35	64	33	29	77	27
B2 26	51	26	31	80	26
B2 46	49	22	24	76	29
MEAN	51.4	24.5	32.8	82.9	27.8
STD. DEV.	5.40	4.22	7.45	11.38	6.18
STD. DEV./MEAN	0.105	0.172	.227	0.137	0.222

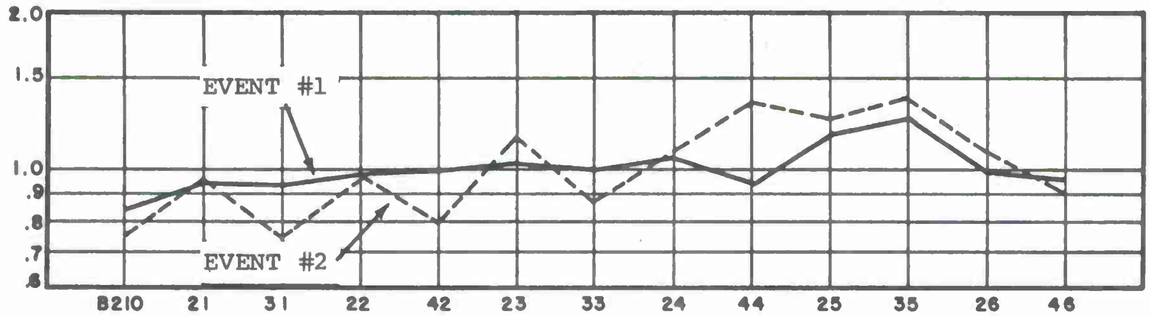
LASA F4 AMPLITUDES (MILLIMICRONS)

STATION	KURILE #1	KURILE #2	MEXICO #3	MEXICO #4	MEXICO #5
F4 10	48	12	38	190	27
F4 21	49	14	38	206	42
F4 31	50	15	39	205	47
F4 22	46	14	39	199	39
F4 42	52	16	40	215	38
F4 23	56	15	38	210	47
F4 33	52	14	45	207	45
F4 24	55	16	52	222	39
F4 44	47	15	49	214	32
F4 25	43	15	42	193	33
F4 35	47	12	39	201	42
F4 26	49	13	35	180	31
F4 46	52	14	35	197	43
MEAN	49.7	14.2	40.7	203	38.8
STD. DEV.	3.67	1.30	5.10	11.4	6.53
STD. DEV./MEAN	0.074	0.091	0.125	0.056	0.168

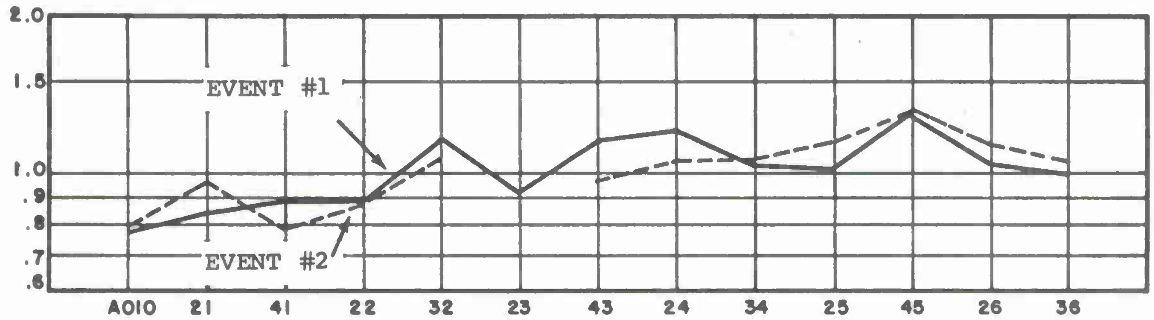
Table 1



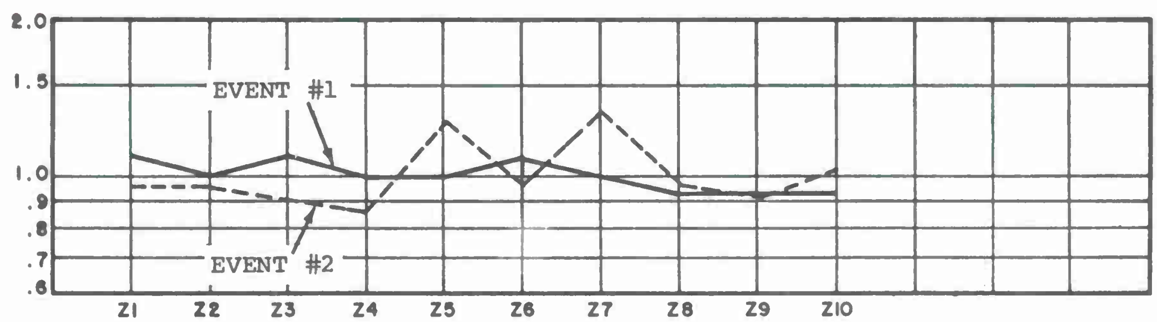
F4 Subarray Normalized Amplitudes for Kurile Events



B2 Subarray Normalized Amplitudes for Kurile Events

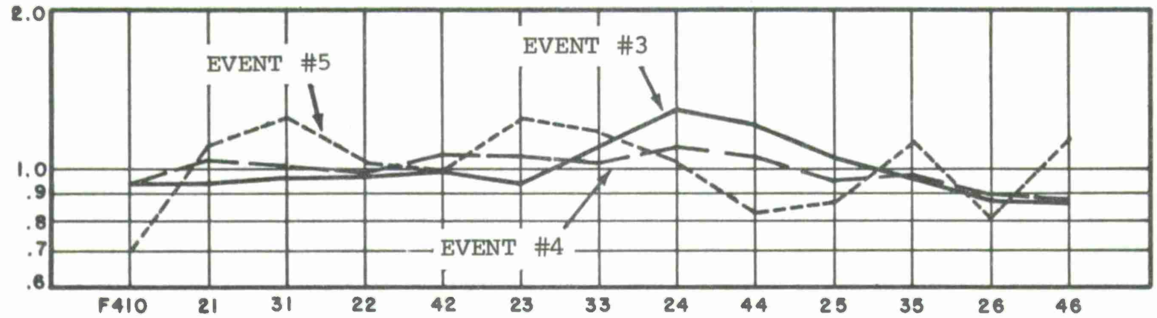


AO Subarray Normalized Amplitudes for Kurile Events

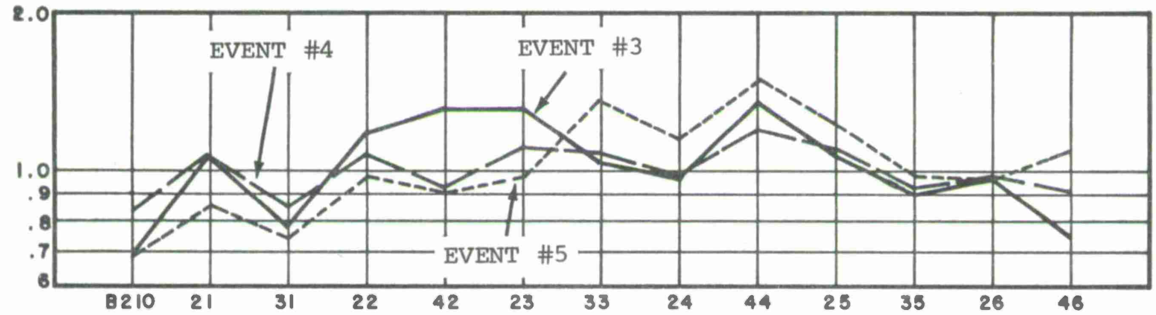


UBSO Array Normalized Amplitudes for Kurile Events

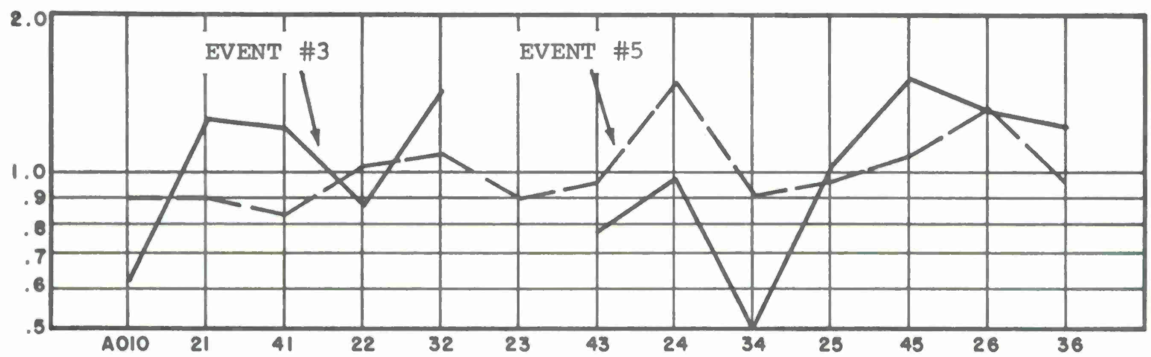
Figure 2



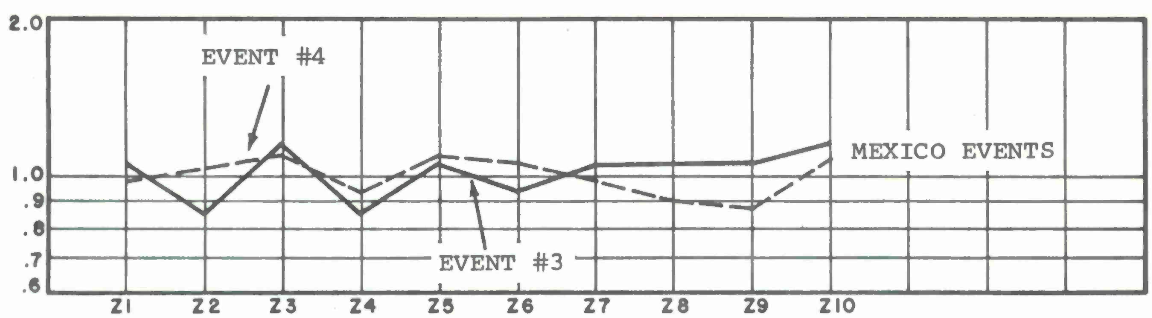
F4 Subarray Normalized Amplitudes for Mexican Events



B2 Subarray Normalized Amplitudes for Mexican Events



AO Subarray Normalized Amplitudes for Mexican Events



UBSO Normalized Amplitudes for Mexican Events

Figure 3

TFSO AMPLITUDES (MILLIMICRONS)

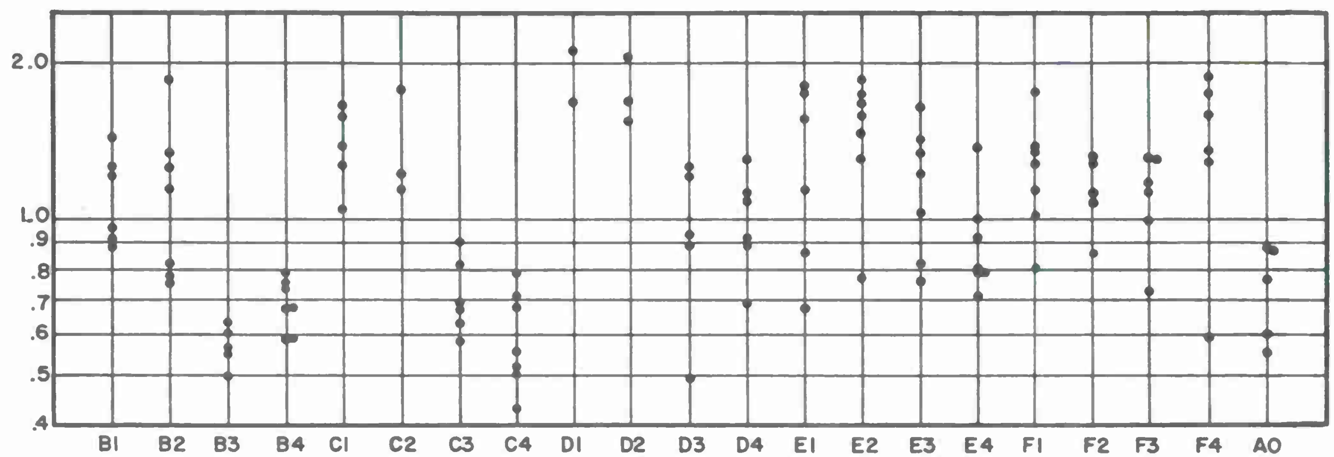
STATION	EVENT #1	EVENT #2	EVENT #3	EVENT #4	EVENT #5	EVENT #6	EVENT #7	STD. DEV. OF NORM. AMPLITUDE
Z17	30	7	12	22	42	-	15	0.31
Z10	27	-	15	15	23	26	9	0.18
Z15	33	5	11	-	17	46	11	0.20
Z23	-	-	14	-	-	54	-	0.24
Z5	37	-	13	13	22	-	9	0.16
Z20	31	-	15	15	24	-	10	0.15
Z29	-	-	12	-	-	42	-	0.13
Z13	31	-	-	-	-	-	-	-
Z2	40	6	15	-	40	42	13	0.21
Z60	33	6	15	-	20	47	11	0.19
Z25	40	8	12	18	40	49	15	0.19
Z71	37	10	12	-	45	-	21	0.35
Z64	32	-	14	19	36	57	15	0.22
Z61	34	11	-	16	-	-	-	0.41
Z68	37	-	13	-	-	-	-	0.03
Z69	44	5	13	16	39	-	23	0.39
Z73	38	10	13	18	43	-	20	0.30
Z66	35	-	13	-	-	-	-	0.01
Z63	32	8	12	27	25	47	-	0.24
Z70	28	-	12	19	42	43	15	0.28
SG-AZ	-	-	10	15	12	42	5	0.30
JR-AZ	41	4	11	-	14	17	12	0.28
LG-AZ	49	8	19	21	20	30	19	0.32
GE-AZ	38	6	10	13	17	22	-	0.18
SN-AZ	30	3	9	12	-	-	6	0.17
HR-AZ	-	10	16	22	20	-	23	0.38
WO-AZ	54	-	13	18	24	23	10	0.31
NL2AZ	23	6	-	26	26	-	12	0.30
Z16	-	-	12	-	-	47	-	0.22
MEAN	35.6	7.1	12.9	18.1	28.1	39.6	13.7	0.25
STD. DEV.	6.95	2.45	2.12	4.27	10.92	12.14	5.27	
STD. DEV. / MEAN	0.195	0.346	0.164	0.236	0.389	0.306	0.385	

Table 2A

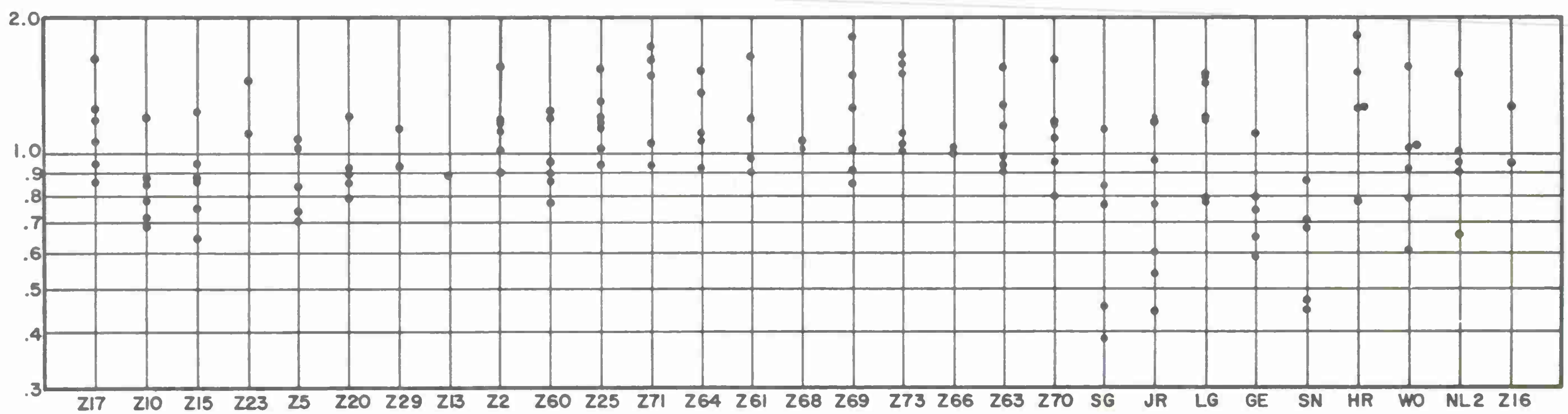
LASA AMPLITUDES (MILLIMICRONS)

STATION	EVENT #1	EVENT #2	EVENT #3	EVENT #4	EVENT #5	EVENT #6	EVENT #7	STD. DEV. OF NORM. AMPLITUDE
B1 10	36	34	11	11	27	49		0.22
B2 10	34	21	13	15	18	42	200	0.39
B3 10	14	17	-	6	-	32	65	0.05
B4 10	17	16	9	9	15	33	80	0.08
C1 10	35	42	18	-	37	70	111	0.27
C2 10	-	-	14	-	40	63	-	0.36
C3 10	16	22	8	7	15	50	-	0.12
C4 10	13	21	5	6	15	40	60	0.13
D1 10	-	-	-	-	47	94	-	0.30
D2 10	39	-	-	-	46	95	-	0.27
D3 10	-	25	14	12	11	49	134	0.27
D4 10	-	30	8	13	20	50	140	0.24
E1 10	22	42	13	21	15	99	-	0.47
E2 10	40	47	15	22	37	82	82	0.36
E3 10	26	22	14	17	17	75	178	0.32
E4 10	18	37	9	11	22	45	85	0.23
F1 10	34	47	16	15	22	62	87	0.30
F2 10	28	23	8	15	24		140	0.23
F3 10	33	31	15	-	25	55	78	0.22
F4 10	34	-	20	19	13	71	202	0.46
AO 10	22	15	10	9		33	-	0.46
MEAN	27.1	28.9	12.2	13.0	24.5	59.4	117.3	0.27
STD. DEV.	19.70	10.82	3.88	6.71	10.00	21.18	48.45	
STD. DEV. / MEAN	0.727	03.74	0.318	0.516	0.408	0.357	0.413	

Table 2B



LASA Normalized Amplitudes for Seven Aleutian Events



TFSO Normalized Amplitudes for Seven Aleutian Events

Figure 4

this plot that LASA amplitude scatter is no greater than TFSO amplitude scatter.

CONCLUSIONS

Seismic signal amplitude scatter is not a unique characteristic of LASA but is a common property of seismic arrays.

APPENDIX A

Normalized amplitudes are used to reduce events of different average signal levels to a common scale. The normalized amplitude $Y_{I,J}$ for Station I and Event J is defined as

$$Y_{I,J} = \frac{X_{I,J}}{GEOMEAN_J}$$

where X is the observed amplitude and geomean is the geometric mean of the observed amplitudes for event J and

$$Geomean_J = Log^{-1}\left[\frac{1}{N}\sum_{I=1}^{N} Log\ X_{I,J}\right]$$

where N is the number of observed amplitudes for event J.

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13. ABSTRACT

Seismic signal amplitude scatter is shown by demonstration to be characteristic of present seismic arrays rather than a unique characteristic of LASA.

14. KEY WORDS

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